Observational Sensitivity to Climate Variability using AIRS/Aqua and MERRA

Thomas Hearty[1], Eric Fetzer[2], Baijun Tain[2], Yuk L. Yung[3], Andrey Savtchenko[1], Mike Theobald[1], Bruce Vollmer[1], Peter Smith[1], Dana Ostrenga[1], Greg Leptoukh[1]

[1]Goddard Space Flight Center (GSFC), Greenbelt, MD 20771 (Thomas.Hearty@nasa.gov); [2]Jet Propulsion Laboratory (JPL/Caltech), Pasadena, CA 91109, [3]Caltech, Pasadena, California 91125

U41B-0017

Cell Phone: 571-490-5016

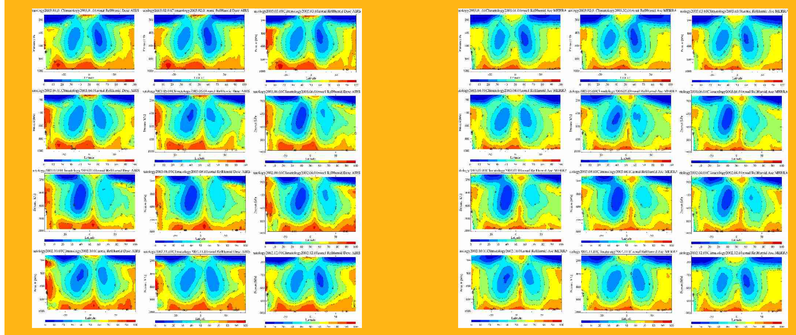
Abstract

The El Nino Southern Oscillation (ENSO) is one of the largest climate variabilities seen in AIRS observations of temperature, water vapor, and clouds. Numerous climate feedbacks are involved in this oscillation. We examine ENSO using observations from the Atmospheric Infrared Sounder (AIRS) and the Modern Era Retrospective-Analysis for Research and Applications (MERRA).

Since sampling can be an issue for infrared satellites in low earth orbit, we examine the MERRA data sampled at the AIRS space-time locations both with and without the AIRS quality control. We estimate the sampling bias of an AIRS climatology and the atmospheric conditions where AIRS has a lower sampling rate and examine the apparent differences in the ENSO based on the different sampling. While the AIRS temperature and water vapor sampling biases are small at low latitudes, they can be more than a few degrees in temperature and 10 percent in water vapor at higher latitudes. While these numbers are small they can be important for understanding climate variability.

Relative Humidity

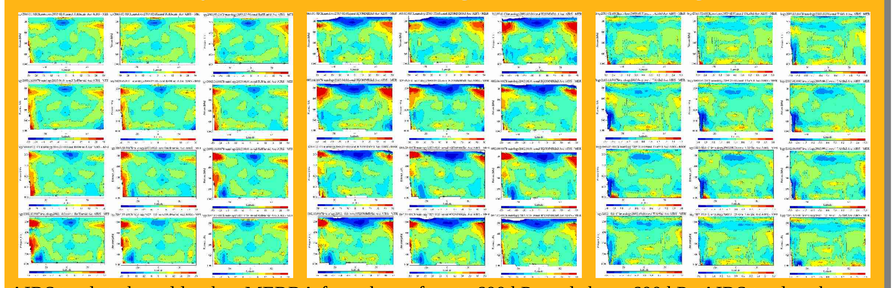
AIRS MERRA



A side-by-side comparison of AIRS and MERRA seasonal variability shows good correspondence although there are some differences (e.g., Over Antarctica).

AIRS - MERRA

relative humidity water vapor temperature

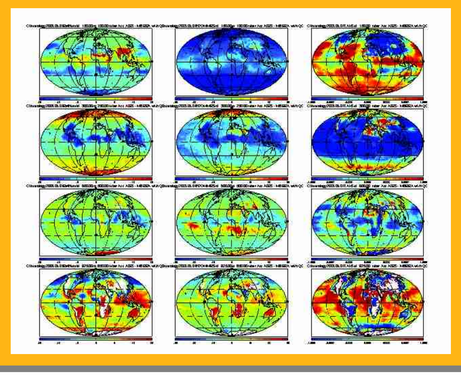


AIRS tends to be colder than MERRA from the surface to 600 hPa and above 600 hPa AIRS tends to be wetter than MERRA. Also, AIRS tends to be drier than MERRA everywhere above 200-300 hPa.

AIRS-MERRA

Relative humidity water vapor temperature

925-850 600-500 300-250 150-100



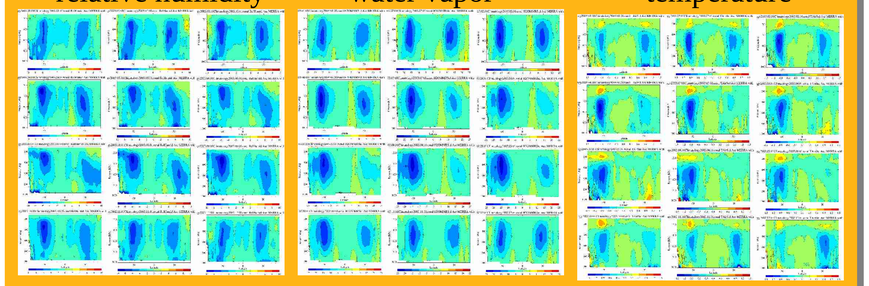
Maps of several layers of relative humidity, water vapor, and temperature from the June climatology show that there is spatial structure in the difference between AIRS and MERRA

Sampling Bias

Since the AIRS instrument is not able to sample every atmospheric state any climatology created based solely on its observations will have a sampling bias. However, since the MERRA data set assimilates data from a wide array of sources, it provides data on atmospheric states where AIRS is not sensitive. We use MERRA to estimate the sampling bias of the AIRS climatology by creating one MERRA climatology sampled at each AIRS time and location for which AIRS was able to obtain a successful retrieval (e.g., the quality was ``good'' or ``best'') and subtracting from it a MERRA climatology that samples each AIRS time and location but without applying the AIRS quality control.

MERRA – MERRA

relative humidity water vapor temperature

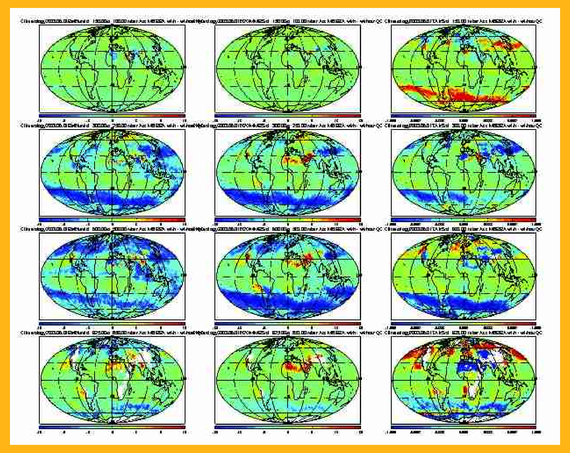


All of the figures show that the largest sampling bias is in the temperate zones.

MERRA-MERRA

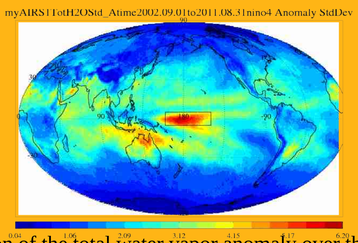
relative humidity water vapor temperature

925-850 600-500 300-250 150-100



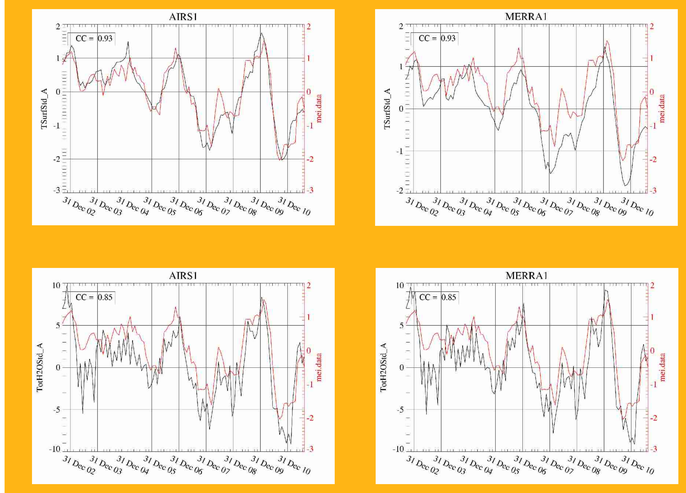
The sampling bias is shown for June. The dry/cold sampling bias in the middle troposphere appears as a warm bias in the upper troposphere. Also, there is moist/warm sampling bias off the west coasts of North America, South America, and Africa and a warm bias over most of the northern temperate ocean.

Standard Deviation of Total Water Vapor Anomaly over 9 years



The standard deviation of the total water vapor anomaly over the 9 years of AIRS observations shows that the Ni\~na 4 region has the largest inter-annual variability in water vapor over the AIRS epoc

Time Series in the Nina 4 region



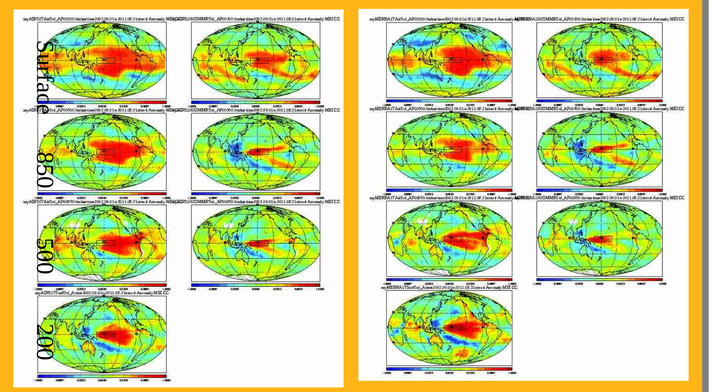
Time series of the AIRS and MERRA surface temperature and water vapor in the Nina 4 region show very good correlation with the Multivariate ENSO Index (MEI).

Correlation with MEI

AIRS MERRA

temperature water vapor temperature water vapor

Surface 850 500 200



Globally, the AIRS and MERRA correlations with MEI are very similar

Conclusions

➔The seasonal variability patterns are similar for AIRS and MERRA.

➔Although the AIRS climatology has some sampling biases they tend to be smaller than other errors and are located in specific geographic regions.

➔Sampling issues can be important for comparisons with gridded data sets like climate models.

➔The AIRS observations capture the variability associated with ENSO.

➔All of the data presented here are available through Giovanni (http://disc.sci.gsfc.nasa.gov/giovanni/overview/index.html)